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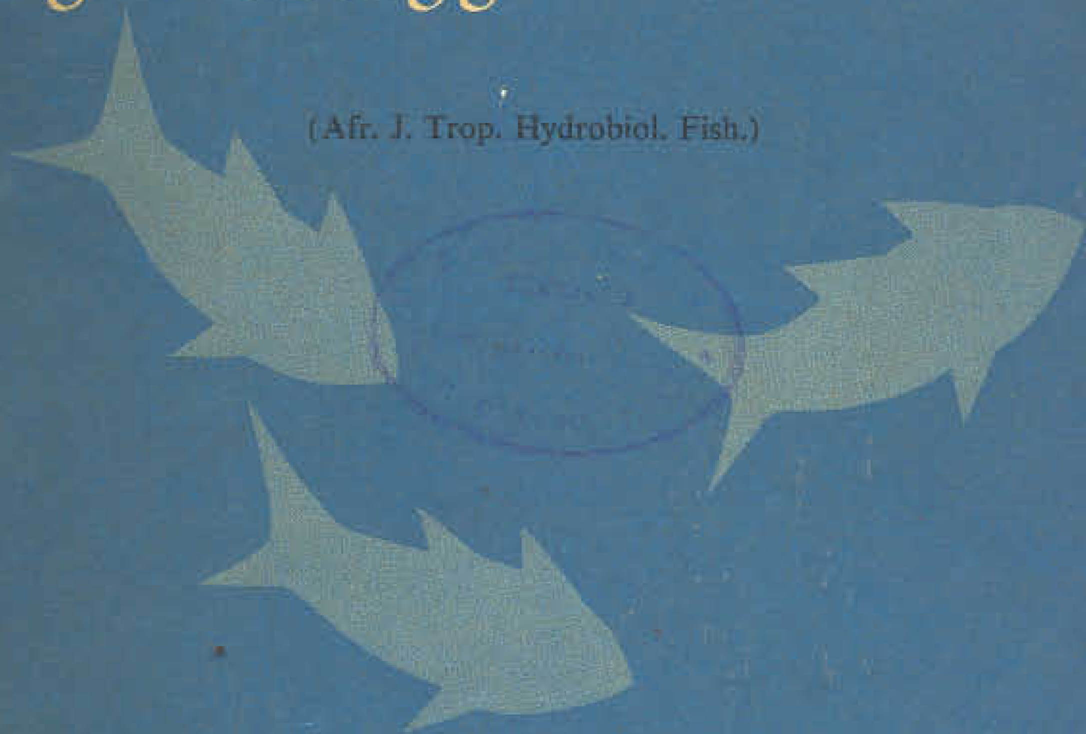

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PAST TRENDS AND RECENT RESEARCH ON THE FISHERIES OF LAKE VICTORIA IN RELATION TO POSSIBLE FUTURE DEVELOPMENTS

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INTRODUCTION

Lake Victoria

Although the fishing industry of East Africa depends upon both marine and freshwater sources, the latter are the more important. The freshwater fishery resources derive from several large and numerous small lakes, rivers, dams, swamps and domestic fish ponds. But of these, Lake Victoria obviously has the greatest single fishery potential.

Lake Victoria is a large (≃69,000 km²), relatively shallow (mean depth=40 m, maximum depth=79 m), single saucer-shaped basin lying in the central part of the great plateau, stretching between the western and eastern Rift Valleys and at an elevation of 1,135 m above sea level. It might have originated in the middle or late Pleistocene from tectonic ponding of westward flowing rivers (WAYLAND 1931; FREENWOOD 1966; KENDALL 1969). Its coastline of 3,440 km is very irregular, especially in the north and south ends. It has numerous sheltered bays and gulfs with reduced light penetration and a distinctive offshore area with greater light penetration. Water income is mostly from direct rainfall (of ≃1,450 mm per year) which has two main peaks (March-May and October-November). This represents 80-90% of the total income and it is balanced by an evaporation of the same magnitude. The rest comes from the slow inflow (replacement time ≃170 years from the streams dominated by the Kagera River and balanced by an equal outflow through the Victoria Nile (TALLING 1965a).

On the basis of bottom deposits three habitat types are recognized: *hard* (sand, gravel or rock), *soft* (silt, mud, humus or clay) and *mixed*. But on the basis of several other ecological parameters (e.g. depth, vegetation, shoreline, etc.), the habitat types are certainly much more numerous (EAFFRO 1951). The total ionic concentration is low. The tropical high temperatures, intense illumination and prolonged growing seasons impart high potential productivity to the lake. The photosynthetic activity per unit area is relatively high (TALLING 1965b) and from the law of latitudes, biological productivity and diversity of Lake Victoria would be expected to be higher than its temperate counterparts—other things being the same.

The fishes of Lake Victoria

The present endemic ichthyofauna of Lake Victoria is believed to have been derived recently, in the geological sense, from the fishes of swamps and rivers that existed in the basin at the time of colonization (GREENWOOD 1951; CORBET 1960) so that many fishes that have not yet fully adapted to the lacustrine regime still display various degrees of anadromesis (WHITEHEAD 1959; CORBET 1961). According to GREENWOOD (1966, p. 20) there are 12 families in the lake which are divisible into six Cichlid genera and 14 non-Cichlid genera. Of the 50 non-Cichlid species 29 are endemic and of the probably more than 127 Cichlid species 124 are endemic so that the lake is endemically a Cichlid lake (two endemic species of *Tilapia* Smith 1840, and, through endemic specification, probably over 120 spp. of *Haplochromis* Hilgendorf 1888). Cichlids have progressed more to the lacustrine environment than most non-Cichlids (CORBET 1961).

Past fishing activities on Lake Victoria

No one knows exactly when fishing on the lake began. But it could be assumed that during the early days adequate catches were obtained with simple fishing gear, from inshore areas only and with little fishing effort. Effective fishing started after the introduction of the gillnets, in 1905, and arrival of the railway, in 1908, at the Nyanza (Kavirondo) Gulf (GRAHAM 1929). These provided the impetus for fishing as an economic activity. Since then, the trends of fishing activities on the lake included:

(a) Expansion of fishing and improvement of fishing gear and craft. The number of fishermen and nets used more or less continued to increase. In addition to the indigenous fishing gears came the flax gillnets (1905), then beach seine nets (early twenties) and, finally, the synthetic fibre gillnets (1952). And the early fishing without (or, with simple) craft became increasingly augmented by paddle or sail-propelled canoes and dhows and many canoes are now fitted with outboard motors.

(b) With increasing total fishing effort the total catch also increased but the relative abundance and length structure of certain species became altered. As a result many fishermen were tempted to reduce the mesh sizes (illegally) of the nets but the catch rates continued to drop after only a short-lived increase.

(c) As the catch rates continued to decline on the traditional fishing grounds the fishermen were forced to venture to more and more offshore waters though many were limited by the lack of suitable vessels.

Governmental attempts to revive economic catch rates from the lake included mesh-size restrictions, search for new fishing grounds and methods and introduction into the lake of exotic fish species (since early fifties). Such measures were very helpful but did not lull the fears nor arrest the declining catch rates, especially with increasing fish demand on the markets that have never been satisfied even during the virgin state of the fishery.

Though several species were threatened by overfishing, large stocks of *Haplochromis* spp. were believed to abound in the lake. The latter were not effectively harvested through the selective properties of the principal commercial gear (gillnet). Thus, fishermen had a "sound reason" for increased use of beach seine nets and smaller mesh gillnets (to catch the small *Haplochromis*), even though the latter deplete potential spawners and the former greatly molest the breeding and nursery grounds of certain species. The paradox of the Lake Victoria fishery, therefore, called for a fishing regime and management strategy which would economically exploit the stocks according to their biological characteristics. This required knowledge of the distribution pattern, extent and magnitude of the lakewide available stocks which was still lacking in 1967.

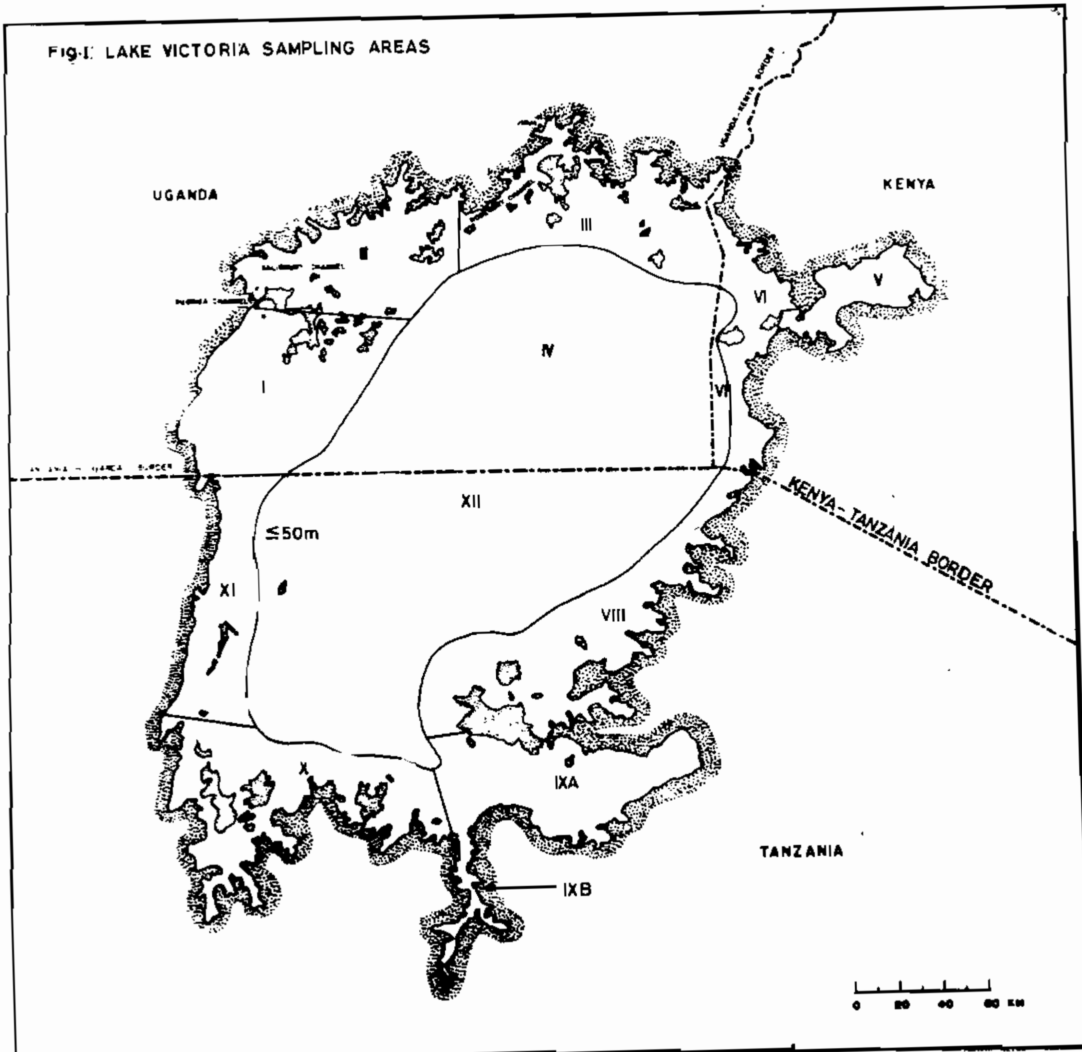


Fig.I: LAKE VICTORIA SAMPLING AREAS

Therefore, the East African Freshwater Fisheries Research Organization (EAFFRO) and UNDP/Lake Victoria Fisheries Research Project (LVFRP) embarked on a lakewide bottom-trawl exploratory survey to bridge this gap. The immediate aims were to derive preliminary estimates of the temporal and spatial distribution pattern, magnitude and relative abundance of the available stocks and to evaluate trawling as a fishing technique for the Lake Victoria fisheries. These would form the foundation for further sophisticated studies and for initial fishery development plans for the lake. The survey was conducted from January, 1969, to March, 1971.

MATERIAL AND METHODS

Lake Victoria was divided into 13 arbitrary areas (Fig. 1), each of which was subdivided into 10 m depth intervals giving a total of 52 strata. These constituted our sampling units. Bottom trawling was conducted with the 180 hp research vessel, *Ibis*, which is 17 m long and is fully rigged for a variety of fishing gear. It is fitted with radar. Two electronic echosounders record both the depth and "biological targets" within the water column beneath the keel and a two-ton capacity hydraulic winch deploys and retrieves the gear. Several types of otter trawl were used but two standard nets (of 2-seam design) were used more frequently. Their headrope lengths were 24 m and 19 m. The various codends used varied mostly in their mesh sizes, 83, 76, 64, 57, 51, 38 and 19 mm stretched). But the 64, 38 and 19 mm mesh codends were used most frequently.

The survey was conducted during 19 cruises, each lasting from one to three weeks. Bottom trawling was possible only in waters deeper than 4 m because of the restrictions imposed by the draught of the *Ibis*. Towing speed was maintained at an average of three knots. The actual fishing duration was mostly 60 minutes and shorter or longer tows were adjusted to hourly catches for subsequent analyses. Trawling was executed on a 24-hour basis but, owing to certain considerations, only hauls made during the day (0700-1900 h) were used for the present purpose. The daylight drags believed to have been "faulty" were also eliminated. Thus, of the 1,141 hourly hauls made over the whole lake, 772 (or 67.7%) qualified for present considerations. Their spatial distribution by each of the 52 sampling units is shown in Table 1.

Certainly there was spatial and temporal disparity in the distribution pattern of exploratory sampling effort. But broad coverage was achieved so that we have not been pusillanimous in considering broad generalizations after making certain assumptions. Our results are tentative, but can serve as a sound baseline for more precise studies for defining the stocks of Lake Victoria. If they are used, however, for immediate fishery developments they should not be welcomed with myopic exuberance.

RESULTS AND OBSERVATIONS

Bottom trawling as a fishing technique on Lake Victoria

Most of the lake was found to be convenient for bottom trawling. The lake is generally shallow (79 m maximum, 40 m mean) and its bottom is almost flat. A few areas with rocks or floating "papyrus islands" could be detected and avoided. With enough expertise, places with very soft mud bottoms are tolerable though the efficiency of the gear is generally reduced. Most of the fishes in Lake Victoria appear to be more demersal than pelagic and bottom trawling was found to be a superior fishing technique over the existing commercial gear, particularly in harvesting the *Haplochromis* spp. As trawls are less selective than the gillnets, trawl catches were more representative of the available stocks.

Tqble I. The Spatial Distribution of Exploratory Effort (One-hour Hauls) in the various sampling units of Lake Victoria

Section of Lake Victoria		DEPTH INTERVAL (m)									No. of Sampling Units
		4–9	10–19	20–29	30–39	40–49	50–59	60–69	70–79	Total	
	AREA										
UGANDA	I	19	27	9	10	7	—	—	—	72	
	II	20	40	21	11	8	—	—	—	100	
	III	16	29	22	12	8	—	—	—	86	
	IV	—	—	—	—	—	27	29	11	67	18
KENYA	V	36	23	—	—	—	—	—	—	59	
	VI	5	14	12	6	14	—	—	—	51	
	VII	—	—	—	—	—	10	8	—	18	9
TANZANIA	VIII	10	26	27	15	13	—	—	—	91	
	IXA	17	31	22	8	6	—	—	—	84	
	IXB	20	9	—	—	—	—	—	—	29	
	X	8	26	6	—	1	—	—	—	41	
	XI	—	3	12	9	12	—	—	—	36	
	XII	—	—	—	—	—	20	14	5	39	25
TOTAL hauls		151	228	130	71	68	57	51	16	772	52
% of total hauls		19.6	29.5	16.8	9.2	8.8	7.4	6.6	2.1	100.0	
% of total area of the lake		9.3	9.2	8.5	7.5	9.3	17.7	20.2	18.4	100.1	

* All hauls made there did not "qualify".
—Such a depth does not exist in the area.

The composition of the common demersal fishes of Lake Victoria

The composition of the demersal fishes encountered during the survey was not qualitatively different from the species common in commercial catches. Of the lake's ichthyofauna, 24 commonest species (excluding the *Haplochromis* taxon) were encountered. These are systematized into 21 genera which fall into 11 families. The *Haplochromis* taxon comprises four monospecific genera and the more important polytypic genus, *Haplochromis* itself, made up of probably more than 120 species (some of which have not yet been described). Twenty of the most common taxa encountered are listed in Table 2. Though with temporal and spatial variations in catch rates and frequency of occurrence, most of them were encountered in all the areas (except areas IV, VII and XII) which are deeper than 50 m. Thus, depth (directly or indirectly) is certainly one of the ecological parameters determining the distribution pattern of the fishes in Lake Victoria.

Batho-spatial distribution pattern and relative abundance of the major demersal fishes as shown by mean catch rates

The mean catch rates for the whole lake indicated in Table 2 were derived from means for the various sampling units. But

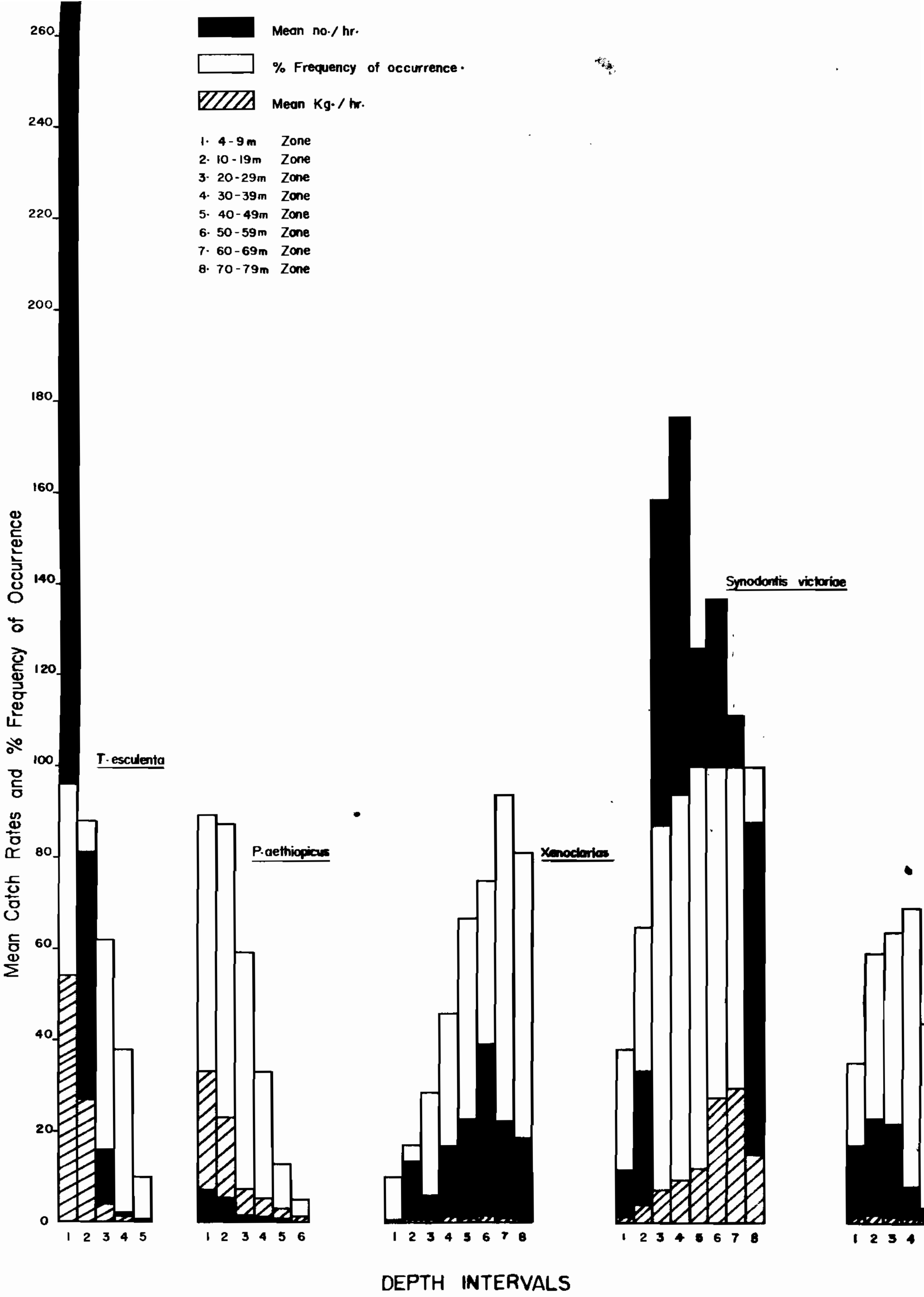
Table 2. Bottom Trawl Mean Catch Rates (weighted by depth interval) of the Various Fishes in Lake Victoria (in kg/h)

Depth (m) Number of hauls	0–9[2] 151	20–19 228	20–29 131	30–39 71	40–49 68	50–59 56	60–69 51	70–79 16
Species:								
Haplochromis spp.[1]	493.8	800.2	639.5	507.5	448.0	486.3	196.3	29.6
Tilapia esculenta	54.1	28.3	4.4	0.5	0.0	—	—	—
T. variabilis	3.2	0.2	0.0	—	—	—	—	—
T. nilotica	10.0	0.9	—	—	—	—	—	—
T. zillii	0.4	0.0	0.0	—	—	—	—	—
T. leucosticta	0.2	—	—	—	—	—	—	—
Bagrus docmac	18.0	39.9	39.3	36.8	34.4	38.8	27.6	0.2
Clarias mossambicus	26.7	37.1	31.6	20.7	15.1	14.5	14.8	7.1
Xenoclarias spp.	0.0	0.1	0.1	0.3	0.4	0.6	0.3	0.3
Protopterus aethiopicus	33.3	23.1	7.3	5.5	1.6	0.5	—	—
Lates niloticus	2.0	0.6	0.4	—	—	—	—	—
Synodontis victoriae	0.4	1.7	7.0	9.0	11.2	26.6	29.4	14.9
S. afrofischeri	0.1	0.1	0.1	0.0	0.0	0.0	0.0	—
Barbus altianalis	0.4	0.5	0.3	0.2	0.2	—	—	—
Labeo victorianus	0.1	0.4	0.0	—	—	—	—	—
Mormyrus kannume	0.4	0.4	0.3	0.4	0.9	0.1	0.0	—
Schilbe mystus	0.9	1.8	1.3	0.6	0.3	0.1	0.0	—
Alestes spp.	0.0	—	—	—	—	—	—	—
Mastacembelus frenatus	0.0	0.0	0.0	—	—	—	—	—
Gnathonemus longibarbis	0.0	0.0	—	—	—	—	—	—
Total	644.0	935.3	731.6	581.5	512.1	567.4	268.4	52.1
No. of species encountered (excluding *Haplochromis* spp.)	19	17	16	11	10	8	7	4

1. For *Haplchromis* spp. only data from small mesh codends (19 and 38 mm) were used.
2. Though the IBIS operated in waters deeper than 4 m, mean catch rates were weighted by the area of the whole depth zone (i.e. 0–9 m).

the mean catch rates for these substrata were first weighted by their corresponding estimated surface areas. Data show that there is a well-defined trend of species distribution by depth. Maximum species diversity occurred in the shallowest depth zone (4-9 m), where 19 species other than the *Haplochromis* spp. occurred, and progressively decreased with depth up to the deepest zone (70-79 m), where only four of the species were present. Four of the major commercial taxa (*Haplochromis* spp., *Bagrus docmac* Forsk 1775, *Clarias mossambicus* Peters 1852, and *Synodontis victoriae* Boulenger 1906) and one minor genus (*Xenoclarias* Greenwood 1958) were found to be eurybathic, *Tilapia* Smith 1840 species and the lungfish (*Protopterus aethiopicus* Heckel 1851), also major commercial fishes, are more or less oligobathic. Their maximum depths of occurrence appear to be as follows: *P. aethiopicus* (50-59 m), *T. esculenta* Graham 1928 (40-49 m), *T. variabilis* Boulenger 1906 (30-39 m), *T. nilotica* Linne 1757 and *T. zillii* Gervais 1848 (20-29 m) and *T. leucosticta* Trewavas 1933 was encountered in waters not much deeper than 10 m. The rest of the species were found in shallow waters but variously extending in waters of intermediate depths (Fig. 2) with

Fig. 2: Mean Catch Rates and % Frequency Occurrence by Depth.



Mean no./hr.
% Frequency of occurrence.
Mean Kg./hr.
1. 4-9m Zone
2. 10-19m Zone
3. 20-29m Zone
4. 30-39m Zone
5. 40-49m Zone
6. 50-59m Zone
7. 60-69m Zone
8. 70-79m Zone
Mean Catch Rates and % Frequency of Occurrence
T. esculenta
P. aethiopicus
Xenoclarias
Synodontis victoriae
DEPTH INTERVALS

Schilbe mystus Linne 1762 and *Mormyrus kannume* Forsk 1775 appearing in the 60-69 m depth zone which is their limit.

In terms of relative abundance the mean catch rates also showed distinct patterns within each species range of distribution. *Tilapia* spp. *Protopterus, Schilbe* and the Nile perch (*Lates niloticus* Linne) were more abundant and more frequently encountered in shallow waters, and progressively became less significant up to their corresponding depth limits. *M. kannume* and *Barbus altianalis* Boulenger 1900 were only slightly less abundant at the deeper end of their range. *C. mossambicus,* though more significant in waters less than 40 m deep, was sparse only in the deepest waters (70-79 m). *B. docmac* and *Haplochromis* spp. were significant almost everywhere but highest catches were constantly recorded in the 10-50 m depth range and very poor catches were always made in the 70-79 m zone. It might be mentioned that *Bagrus* follows *Haplochromis* more than does any other species in terms of relative abundance, depth preference and diel vertical migrations. These, together, emphasize a strong *Bagrus/Haplochromis* marriage in their predator/prey relationship. Finally, *S. victoriae* and *Xenoclarias* were the only eurybathic fishes in Lake Victoria which were less abundant in shallow waters but progressively became more significant with increasing mean depth. Length frequency analyses also showed that the mean sizes of these fishes, like that of *Haplochromis,* varied directly with mean depth.

The mean catch rates in terms of numbers and weight and the percentage frequency of occurrence by depth are shown in Fig. 2 for five of the species. Besides depth, there are obviously other ecological factors such as bottom type, 0_2-concentration, shoreline development, etc. (see WELCOMME 1964), which contribute to the distribution patterns of the fishes in the lake. But such a detailed analysis is outside the purview of our present broad considerations on the stocks.

Present estimates of "Minimum Standing Stocks" of the major fish species in Lake Victoria as derived from bottom trawl data standing stock estimates

We used the mean catch rates to estimate the minimum standing stocks of each species by depth interval. We followed the methods outlined by ALVERSON and PEREYRA (1969)—using mean catch rates (Table 2). average towing speed (3.0 knots=16,668 m h^{-1}) average gape of the trawl ($\simeq$9 m, horizontal opening) and estimated area of the stratum considered. Thus, from the equation given by Alverson and Pereyra, we have simply:

$$B = \frac{C\,A}{Q}$$ where B=estimated biomass.

C=Average catch rate (kg/ha).
A=Area (ha).
Q=Estimated gear efficiency.

We had to assume that hauls were effectively randomized within each stratum, that catch rates were directly proportional to the density of the fish on the grounds, and that the absolute fishing performance of the gear was unity on each of the grounds sampled. However, certain considerations such as selectivity of the trawl, spatial and temporal disparity in our sampling patterns, possible existence of avoidance or escapement and of herding b ythe trawl doors or warps, etc., impose limitations to the correctness or precision of our estimates. The estimates derived are, therefore, merely the order of magnitude of the demersal fish stocks in the lake susceptible to bottom trawls.

The estimates are given in Table 3. It was found that the *Haplochromis*[1] group is

[1] Note, however, that for *Haplochromis* only the data with small mesh (19 and 38 mm) were used

by far the most preponderant taxon in the lake, where other taxa combined constitute just a little more than 10% of the total estimated ichthyomass. However, the significance of *Tilapia* spp. and *Protopterus* may have been underestimated since we did not sample the 0-4 m depth where these fish could have been more concentrated. It has already been pointed out that the central portion of the lake is, by species and quantity, poor in demersal fish concentration. It has thus been estimated from our data that 30% of the lake surface area (0-30 m depth range) contains at least 50% of the estimated demersal biomass whereas over 18% of the area (70-79 m zone) carries only 2% of the biomass (see Table 3). This is relevant when considering the tempo and incentive for geographic expansion of fishing to deeper and more offshore waters.

Table 3. Present estimates of "Minimum Standing Stocks" (in metric tons) of the demersal fishes in the various depth strata of Lake Victoria

Depth stratum (m)	0–9	10–19	20–29	30–39	40–49	50–59	60–69	70–79	Total
Estimated biomass	78,735	117,855	96,189	78,884	77,356	145,275	71,291	13,422	679,007
% of total biomass	11.6	17.4	14.2	11.6	11.4	21.4	10.5	2.0	100.1
% of surface area	9.3	9.2	8.5	7.5	9.3	17.7	20.2	18.4	100.1
% of biomass/unit % area	1.2	1.9	1.7	1.5	1.2	1.2	0.5	0.1	

"Potential yield" for Haplochromis

The "harvestable" *Haplochromis* (i.e., catchable in 19 and 38 mm mesh codends) biomass estimate of about 600,000 metric tons was used to derive a preliminary estimate of "potential yield" using GULLAND'S (1970) approximate model for estimating potential yield from data on virgin ichthyomass:

$C\,max \doteq 0.4\,MB_0$ where

$C\,max$ = maximum potential yield
M = coefficient of natural mortality
B_0 = virgin ichthyomass

Note that M, in an unfished fishery, would be equal to the total mortality. The present *Haplochromis* harvest of about 20,000 metric tons (1969) was considered a small fraction of the standing stock so that the present biomass, B, is nearly equal to the virgin biomass, B_0 (or, roughly B=0.9B). For different species of *Haplochromis*, M is likely to vary between 0.5 and 1.5 depending on mean specific size. Knowledge of mortality coefficients in tropical fish stocks is very diffuse. But we could use H. REGIER'S (personal communication) guesstimate of 0.8 as the average M value for all *Haplochromis* of "harvestable" size. Thus,

$$C\,max\,(0.4)\,(0.8)\,\frac{(B)}{(0.9)}$$

and this gave us the *Haplochromis* "potential yield" which is within the magnitude of 200,000 metric tons. This figure refers to the order of magnitude of the biological potential yield under proper and effective fishing regimes. Higher *Haplochromis* catches could probably be sustained.

PAST TRENDS IN THE FISH CATCHES FROM LAKE VICTORIA

Available catch statistical data for the whole lake have many gaps. Some catch records give figures for only a few species, specific landing places, type of gear, total weight or only numbers of fish. But we can use Tanzania's annual catch estimates for 1958-70 to get a rough picture of the trends of the various fish catches in that part of

Trends in Catches and Fishermen, of the Tanzania part of Lake Victoria (1958-1970)

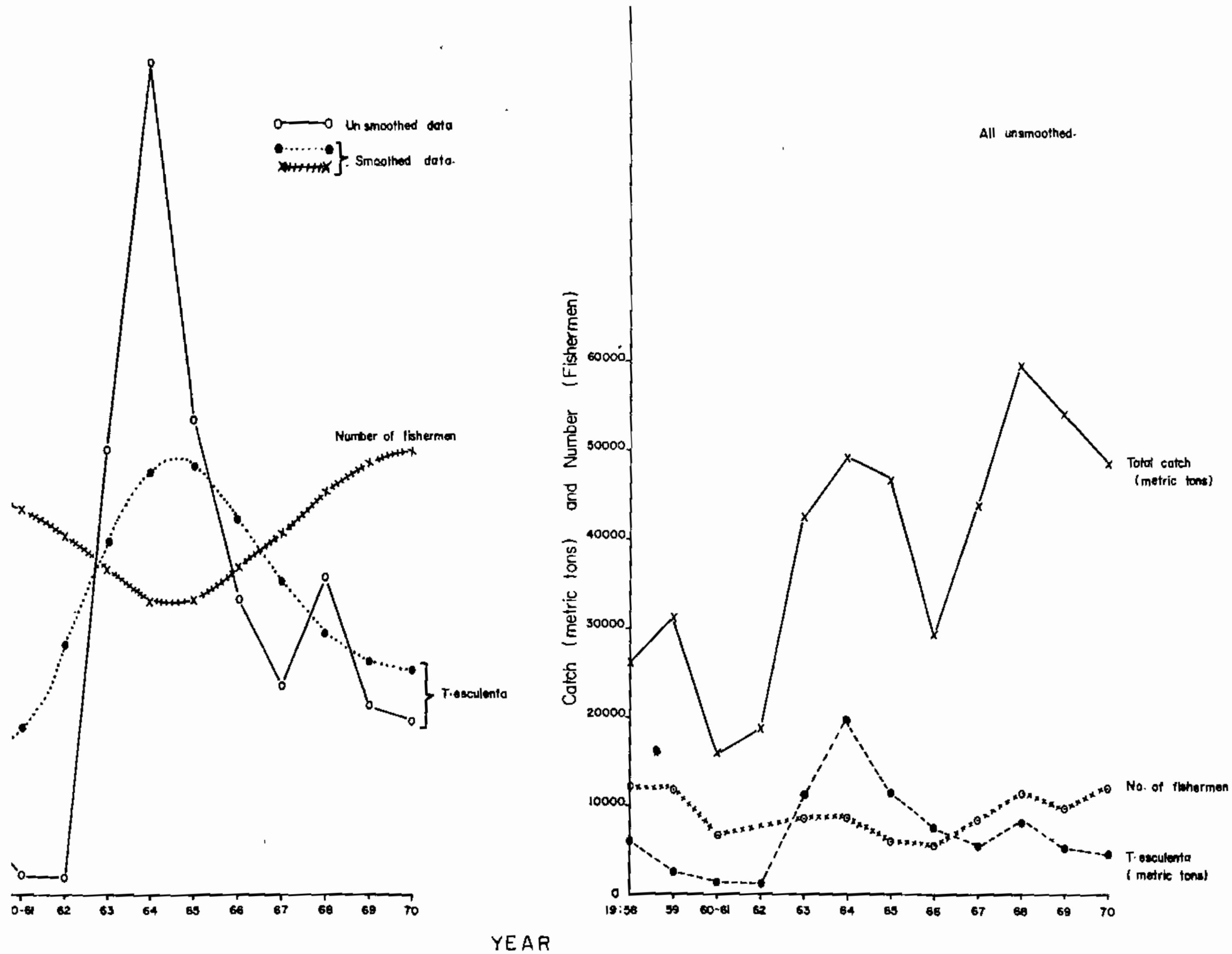


FIG 4 : General Trends in Catches from the Tanzania part of Lake Victoria (1958-1970)

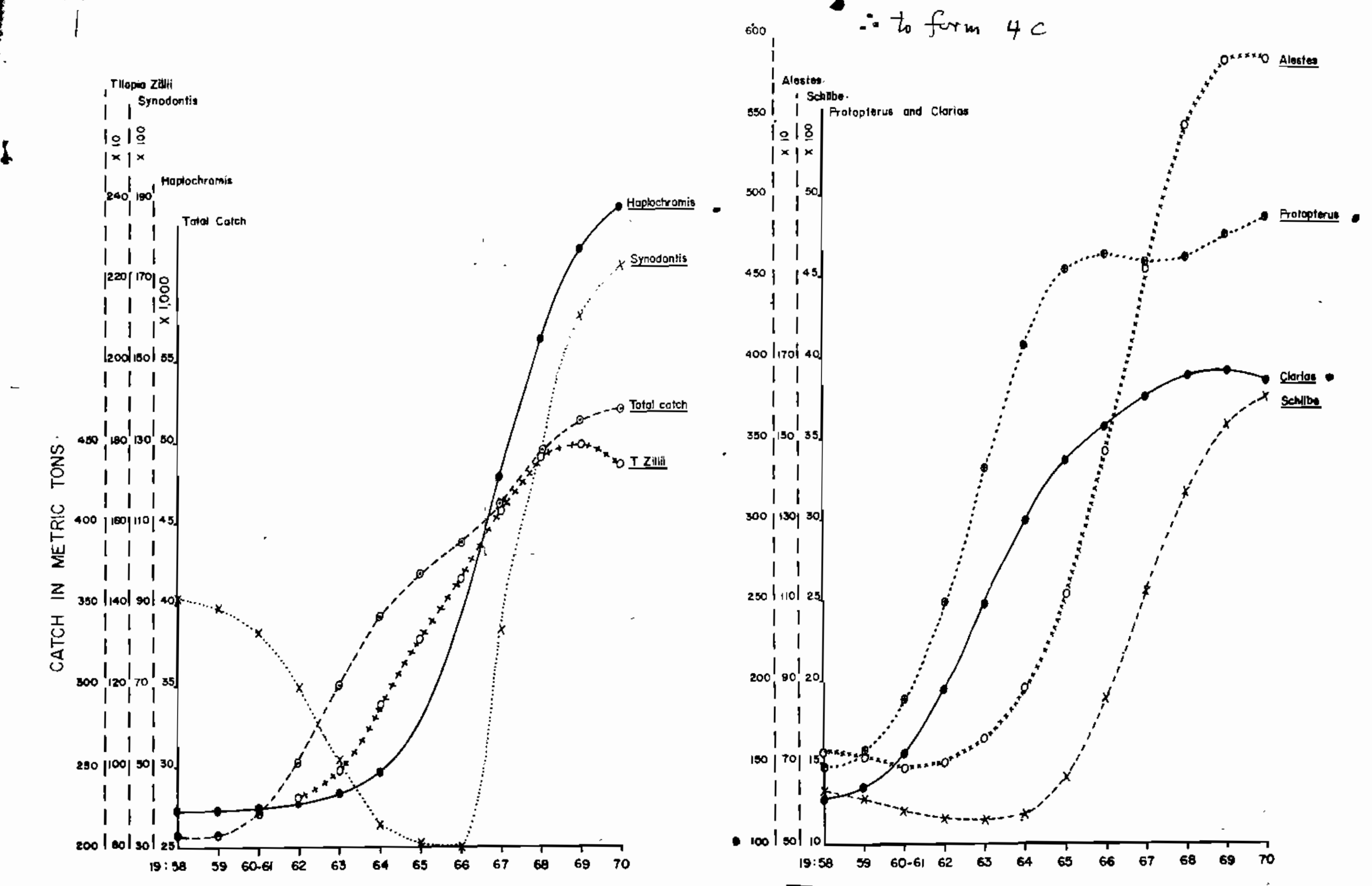


FIG 4 : General Trends in Catches from the Tanzania part of Lake Victoria (1958-1970)

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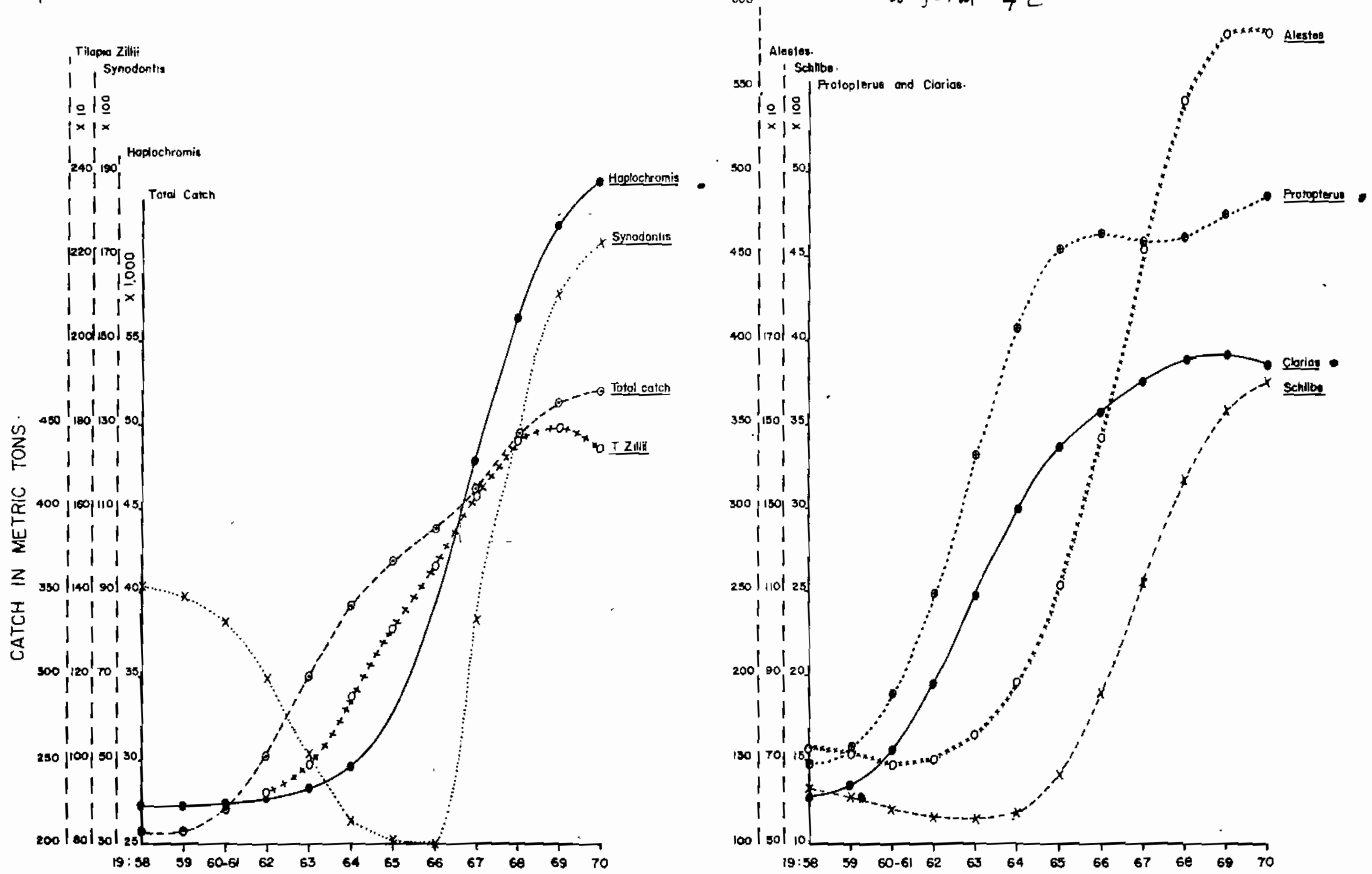

Lake Victoria over the period. The trends could be expected to vary from different areas (depending on ecological and fishing regimes). The Tanzania part of Lake Victoria, being more productive and constituting over 50% of the whole lake surface area, could be assumed to represent the lake for our present generalizations.

Catch estimates from the Tanzania part of Lake Victoria, as supplied by the fisheries department, are reproduced in Table 4. Other relevant parameters are also included. Total catches, *T. esculenta* catches and estimated number of fishermen per year are graphed in Fig. 3a. Because of the great amplitude in the fluctuations, data were intuitively "smoothed" out as shown in Fig. 3b for *T. esculenta.* Only the smoothed data for the number of fishermen are plotted in Fig. 3b, and the depression in the curve was caused by the reduction of their numbers following the rise of water level after the 1961 record of heavy rains. Data for other species were also smoothed out and are shown in Fig. 4.

From Figs. 3b and 4, it can be seen that there has been an increasing trend in the total annual catches over the period though the number of fishermen increased only slightly after the floods. The increase in total catch was obviously through the increased catch per fisherman and through increasing landings for certain individual species. The individual species seem to fall into three groups. All the species in the top panels of Fig. 4 appear to be reaching, or have reached, their maximum peaks. From the behaviour of the smoothed trend curves of this group, it could be suggested that *Haplochromis, Synodontis* and *Schilbe* are the only taxa whose catches are still tending to increase. In which case, much increased catches for *T. zillii, Protopterus, Clarias* and *Alestes* would not be expected in the future under similar ecological conditions. However, evidence adduced from bottom-trawl data seems to suggest that in this group of seven taxa only *Haplochromis* and *Synodontis* may be capable of increased yields. *Synodontis victoriae* is more abundant in the almost virgin deep waters and *Haplochromis* is a ubiquitously preponderant taxon. A second group consisting of *T. esculenta, Bagrus* and *Barbus,* showed an increasing trend for a short while and then continued to decline. Because the peak catches came as an aftermath of the floods, it is apparent that the heavy rains helped to rebuild the populations of the species (WELCOMME 1966). Secondly, the peak period followed the lifting of mesh size restriction. *T. esculenta* is known to have been overfished (GRAHAM 1929; GARROD 1961a). Its mean catch rate was 7.8 fish per net of 127 mm mesh in 1928, but the average figure for 1951-56 was 2.0 (LVFRS 1957-58). Further, the ratio of the 114 mm-127 mm mesh catches was only 0.39 in 1927-28 and had risen to 2.7 in 1957. The evidence of intense fishing is complemented by a mathematical model in which the predicted length composition was calculated on the assumption that in 1928 $f \simeq 0.5$ but was 1.5 in 1957 (BEVERTON 1959, pp. 23-24). If *T. esculenta* has been overfished, *Bagrus* and *Barbus* which show a similar trend, might have been overfished also on the commercially fished grounds. Thus, in this case, too, higher catches in the near future under similar conditions might not be anticipated. This is in agreement with BEVERTON'S (1959) prediction that decreasing the gillnet mesh size would decrease the catches of these three taxa, though not necessarily due to depletion of the stocks. The third group consists of *Labeo, T. variabilis* and *Mormyrus.* The trend curves amply show the continuously declining annual catches and the apparent rebuild-up of the stocks (or catches!) after the rains were almost negligible. There is no doubt that *Labeo* has been overfished (GARROD 1961; CADWALLADR 1969) and, by inference, *T.*

Table 4. Annual commercial landings (in metric tons) from the Tanzania waters of Lake Victoria

	1958	1959	1960/61*	1962	1963	1964	1965	1966	1967	1968	1969	1970	Average catch/year	%
Species:														
Haplochromis spp.	4,736	4,219	2,490	2,985	7,452	3,964	2,631	1,928	14,471	21,063	20,527	17,716	8,682	22.4
Tilapia esculenta	6,077	2,571	1,422	1,408	11,042	19,789	11,722	7,642	5,736	8,176	5,230	4,911	7,144	18.4
T. variabilis	2,092	2,134	1,538	1,880	2,135	1,469	958	922	1,360	1,499	1,452	1,025	1,539	4.0
T. zillii	—	1.4		37	476	294	273	396	358	725	292	423	328	0.8
Bagrus spp.	5,528	12,420	5,250	9,118	10,482	14,827	14,076	11,213	9,105	9,239	11,085	8,422	10,068	25.9
Clarias spp.	916	1,394	1,303	1,078	2,750	2,499	6,059	2,312	2,802	7,164	3,852	2,860	2,916	7.5
Protopterus spp.	1,566	1,172	1,701	1,051	3,628	3,699	8,462	3,327	3,098	5,125	5,005	4,985	3,568	9.2
Synodontis spp.	759	2,651	760	1,423	1,086	968	152	198	1,212	2,248	2,695	2,237	1,366	3.5
Barbus spp.	306	481	371	127	466	464	517	244	1,177	476	299	320	437	1.1
Labeo spp.	2,760	1,722	255	97	1,052	398	1,017	279	1,493	583	599	708	914	2.4
Mormyrud spp.	608	1,566	510	339	398	524	599	198	1,111	426	299	236	568	1.5
Schilbe spp.	726	907	212	149	1,369	274	241	396	1,383	1,818	1,595	1,612	890	2.3
Alestes spp.	161	208	112	22	206	244	158	141	446	757	997	233	308	0.8
Other spp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total catch	26,235	31,302	15,924	18,815	42,542	49,413	46,863	29,198	43,752	59,353	53,927	48,292	38,801	
Total fishermen	12,150	12,000	6,864	?	8,629	8,659	6,077	5,795	8,413	11,517	9,738	12,091		
Total canoes	2,050	2,131	1,226	?	1,719	1,740	1,289	1,230	1,815	2,538	2,495	3,785		
Total gillnets	48,582	62,333	37,202	?	51,557	51,524	50,488	45,871	73,037	80,573	79,030	133,979		
Mean catch/fishermen	2.2	2.6	2.3	?	4.9	5.7	7.7	5.0	5.2	5.2	5.5	4.0		
Mean catch/canoe	12.8	14.9	13.0	?	22.2	28.4	36.4	23.7	24.1	23.4	21.6	12.8		
Mean catch/net	0 54	0.50	0.43	?	0.83	0.96	0.93	0.64	0.60	0.74	0.68	0.36		
Average men/canoe	6	6	6		5	5	5	5	5	5	4	3		

* June 1960 to June 1961.
Data from Tanzania Fisheries Annual Reports.

variabilis and *Mormyrus* could be assumed to have been overfished also. In that case, the biological potential of these three taxa might have been severely affected so that their future catches would probably continue to decline.

DISCUSSION

Past trends and present estimates of the fish stocks in Lake Victoria in relation to possible future developments

Commercial catches and experimental biomass estimates are presented in Table 5 for purely relative comparison. Data suggest that the relative abundance (as %) of the various species in commercial catches, under present fishing practices, and in the experimental biomass estimates are at variance. Some species appear relatively more important in commercial catches than suggested by their biomass estimates. Besides, their mean annual catches for the period 1958-70 are variously higher than their catches in 1970.

Table 5. Commercial Catches and Demersal Biomass Estimates of the Major Commercial Fishes from the Tanzania Part of Lake Victoria

Species	Catch estimates				Experimental estimates	
	1970	%	Mean 1958–1970	%	Biomass	%
Haplochromis ssp.	17,716	38.8	8,682	22.4	321,282	82.94
Tilapia esculenta	4,911	10.7	7,144	18.4	9,569	2.47
T. variabilis	1,025	2.2	1,539	4.0	88	0.02
T. zillii	423	0.9	328	0.8	6	0.00
Bagrus	8,422	18.4	10,068	25.9	22,130	5.71
Clarias	2,860	6.3	2,916	7.5	14,138	3.65
Protopterus	4,985	10.9	3,568	9.2	5,021	1.30
Synodontis	2,237	4.9	1,366	3.5	13,256	3.52
Barbus	320	0.7	437	1.1	77	0.02
Labeo	708	1.5	914	2.4	53	0.01
Mormyrus	236	0.5	568	1.5	119	0.03
Schilbe	1,612	3.5	890	2.3	547	0.14
Alestes	233	0.5	308	0.8	—	—

These species include *T. esculenta, T. variabilis, Bagrus, Barbus, Labeo* and *Mormyrus* —species that have already been shown or inferred above to have been overfished. *Haplochromis* and, though only to a slight extent, *Synodontis (victoriae)* are less important in commercial catches than indicated by their standing stock estimates. Their mean annual catches are lower than their 1970 catches and have been shown to be capable of sustaining higher catches. This situation would be expected if present fishing practices are "too effective" to capture the first category of fishes and "ineffective" to harvest the second category. Data presented indicate that most of the fishes in the former category prefer shallow waters where commercial fishing has been most concentrated. *S. victoriae* is more abundant in deep waters where commercial fishing is not known to have been significant and the small but ubiquitously preponderant *Haplochromis* are not effectively harvested by present fishing methods.

Thus, for full utilization of the fishery resource there is need for modification of fishing practices so that the commercial harvest is concordant with the available stocks.

According to our results, trawling, as a supplementary fishing method which has already been proposed by the partner states, would be adequate. But, owing to the indication that certain species in the lake are already much below the peak of their biomic optimum, planning for a trawl fishery on Lake Victoria as a sound economic enterprise requires many considerations which include:

(1) Trawl catch rates are superior to and more representative of the available stocks than gillnet catches. But exploratory data show that demersal species diversification and biomass density progressively decline with increasing mean depth. The major oligobathic species are the most popular, and many show signs of overfishing. Thus, the tempo and incentive for trawling in deep water (say 30-79 m) may be limited whereas trawling in shallow waters would constitute a collision between the extant gillnetters and would intensify the fishing stress on the already declining species.

(2) Trawls, being less selective, would capture even the immature of various species such as *Bagrus* (whose juveniles and adults are found on the same grounds) and *Tilapia* spp. Besides, trawling in shallow inshore waters might greatly molest the breeding and nursery grounds of certain species whose biotic potential would thus be rapidly undermined.

(3) Data suggest that economic trawl catches from waters deeper than 30 m would be expected from *S. victoriae*, *C. mossambicus* and *B. docmac*. However, the most trawlable resource is the *Haplochromis*. These fish are the most abundant (over 80% by weight) and are larger in deeper waters. But consumer tastes in some areas have a tendency to disregard these fish. On the other hand, considering the world human food balance and the incidence of protein malnutrition in developing East Africa, *Haplochromis* would be best exploited for direct human consumption. In that case, it would appear necessary to conduct an effective educational nutrition campaign and/or develop processing techniques so that the *Haplochromis resource* becomes directly acceptable at least to the protein deficient majority. It must be pointed out that, so far, canning or making fish meal are not feasible processing methods. The tin has been found to cost more than the fish it would contain; and fish meal production appears to be both trophically uneconomic and economically unprofitable and is unsuited for marketing to the local population most in need of additional protein.

Hence, in order to generate efficient fishing and full fishery utilization regimes for rational management strategy, and spread the resource for the benefit of the many who definitely need it requires carefully considered planning for which bio-socio-economic studies are still needed. As such, commercial trawling on the lake should not be permitted to develop more rapidly than the means of ensuring effective utilization of the resource.

SUMMARY

EAFFRO and UNDP/LVFRP bottom-trawl exploratory data have been used to describe the depth distributional pattern, relative abundance and magnitude of the demersal fishes in Lake Victoria. The results have been compared with the commercial catch estimates, and various interpretations of the trends in the annual catches and experimental biomass estimates in relation to possible future developments of the fishery have been suggested. Though it is highly desirable to develop the fishery such as by supplementary trawling, certain social and biological consequences and considerations indicate that the establishment of a sound commercial trawl fishery on Lake Victoria

needs to proceed in graded steps guided by several research disciplines.

The past trends of the fisheries of Lake Victoria are briefly considered. Recent exploratory bottom trawl data, by EAFFRO and UNDP/LVFRP, have been used to define demersal fish stocks of Lake Victoria in terms of their magnitude, relative abundance and distribution pattern by depth. Existence of disparity between the relative abundance of the various species in their commercial catches and in their present biomass estimates is pointed out and the various aspects associated with the necessary modification of the fishing practices are discussed. Further and continuing research of the bio-socio-economic vectors of the fishery will be necessary in order to generate the rationale of an efficient fishing regime for a rational management strategy and realistic utilization of the fishery resource.

RESUME

On considère brièvement l'historique des pêches du lac Victoria. Des données récentes obtenues à l'aide de chaluts d'exploration de fond par EAFFRO et le Projet de recherche des pêches du lac Victoria du PNUD on été utilisées pour définir les stocks de poisson démersaux du dit lac en ce quit concerne leur importance, leur abondance relative et leur distribution par rapport à la profondeur. On souligne le déséquilibre entre la représentation des diverses espèces relatif aux captures commerciales et aux estimations de biomasse et on examine les aspects en rapport avec les changements s'avérnat dans les pratiques de pêche. Il est nécessaire de poursuivre la recherche sur les vecteurs bio-socio-économiques de la pêcherie, afin d'établir la rationale d'un régime de pêche efficace pour la planification et l'utilisation des ressources des pêches.

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